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QUARTERLY REPORT NO. 1

PROJECT NO. 198

INDUSTRIAL AND OTHER APPLICATIONS OF RADIOISOTOPES

SEPTEMBER 1, 1951, to DECEMBER 31, 1951

I. INTRODUCTION

In keeping with the obligation of the State Engineering Experiment Station to provide for the development of new tools for the benefit of Georgia, a program to study the industrial and other applications of radioisotopes has been initiated.

The use of radioisotopes as a research tool is by no means a recent development. Naturally occurring radioisotopes such as radium and polonium have been used since their discovery in 1898. Isotopes having their activity induced by bombardment in particle accelerators have been used in biological, medical and physical research for more than twenty years. Unfortunately, these radioisotopes could only be produced in microscopic quantities and the cost of production was extremely high.

The successful operation in 1942 of the first chain reacting pile or nuclear reactor made it possible to produce radioisotopes in tremendous quantities and at relatively low cost. The majority of these radioisotopes appear as by-products in the routine production of plutonium by nuclear reactors. Others are placed within the reactor as stable isotopes, subjected to intense neutron bombardment and are removed as radioisotopes. Still others are produced, as they have been for years, by bombardment in particle accelerators except that more modern techniques make possible increased yields and reduced production costs.

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During the years since 1946 when the reactor produced radioisotopes first became available to users outside of the Atomic Energy Commission, the number of applications or uses has increased tremendously. Despite this factor, the supply remains so far in excess of demand that practically all of this material is disposed of as waste. The problem of how this material can be utilized has been the subject of intensive research sponsored by the Atomic Energy Commission.

The program which has been started at the State Engineering Experiment Station is much less ambitious than that mentioned above as a study of the utilization of fission products but is no less important.

II. OBJECTIVES

The principal objectives of the program can be outlined briefly, and the outline will serve to show the latitude of investigation which is to be followed.

1. A review of the literature on applications in engineering, industry, medicine and related fields.
2. A study of the properties of various radioisotopes and their advantages or disadvantages for particular applications.
3. A study of the requirements for safe handling of radioactive materials, the protection of personnel, the disposal of waste products, etc.
4. Development of laboratory facilities and special instruments for measurement and control.
5. Experimental work and development on particular applications of interest to industry and the medical profession of the region.

6. Development of a program by which the State Civil Defense Agency may be assisted in the problems concerned with Radiological Defense.

III. PROGRESS

The progress made on the various aspects of this program will be listed in an order corresponding to the outline given above.

1. A review of the literature on applications in engineering, industry, medicine and related fields.

Since the literature directly or indirectly pertaining to each of the items included within the scope of this program has already reached mountainous proportions, it was considered necessary to develop a systematic perusal of this literature. Fortunately, the greater majority of all the papers pertaining to this field are abstracted in "Nuclear Science Abstracts" and copies of this publication are available at Georgia Tech. It is planned that all back issues be scanned for abstracts of papers of interest and that a card file be started to include all of these abstracts.

Following this an attempt will be made to procure copies of those papers containing information of particular value to the project. This will be aided by the addition of many papers already collected by staff members of the Experiment Station.

This work is of necessity progressing at a slow rate, but there is no pressing need to complete this phase within any time limit. It is planned, however, that the index file will contain enough information by the end of the next quarter (March 31, 1952) to be used for reference.

2. A study of the properties of various radioisotopes and their advantages or disadvantages for particular applications.

The particular application of radioisotopes that has been considered to date is the therapeutic action of intense gamma radiation on malignant growths in human tissue. The induced activity of the radioisotope cobalt 60 and the fission product radiocesium 137 have been investigated as possible sources of intense, high energy gamma radiation for the treatment of malignant growths. Even though this particular problem is temporarily sidetracked because of a shortage of high specific activity radiocobalt, it is expected that a unit will eventually be constructed and tested at Georgia Tech for use in cancer treatment at the Steiner Cancer Clinic, Grady Memorial Hospital. This type of unit offers many advantages over conventional X-ray units in the treatment of cancer, and its development will increase the number of weapons against cancer at the disposal of the radiologist. Preliminary plans have been completed for the development of this unit.

Another medical application of radiocobalt is its use in the interstitial and intracavitary needles used in the treatment of localized cancer, where X-ray treatment is not so effective. This use of radiocobalt will largely replace the more expensive radium needles with no apparent reduction in effectiveness. About 100 of these needles will be prepared at Georgia Tech for use at the Steiner Clinic and at the Winship Clinic in Atlanta.

3. A study of the requirements for safe handling of radioactive materials, the protection of personnel, the disposal of waste products, etc.

The effort here has been devoted to the accumulation of information pertaining to the control of the radiations emitted by radioisotopes. The present plan is to develop the technique of safe handling of radioisotopes,

the personnel protection program and the waste disposal problem as the use of radioisotopes by the Experiment Station increases. In this way we will accumulate personnel who have had a proper introduction to the hazards involved and who will be aware of the precautions necessary for their safety. It is anticipated that this will involve only a few people during the first year.

4. Development of laboratory facilities and special instruments for measurement and control.

In order to properly evaluate the many instruments of the same type which are now available from commercial outlets, it became necessary to acquire catalogs from each manufacturer. This accumulation of catalogs has required a great amount of time, but will now enable us to purchase the best instruments available. Since the instrument requirements of this laboratory far exceed the number that can be purchased with the limited funds available, it is planned that certain key instruments will be purchased this year and the remainder filled in by purchase on subsequent appropriations.

5. Experimental work and development on particular applications of interest to industry and the medical profession of the region.

The preliminary investigations on the application of radiocobalt or radiocesium in medicine were described in Part III, Sect. 2, above, but none of the experimental work has been completed.

6. Development of a program by which the State Civil Defense Agency may be assisted in the problems concerned with Radiological Defense.

One of the fundamental problems in any Radiological Defense program is the difficulty involved in supplying reliable instruments for use by the survey teams. Because of the large number of instruments involved,

the routine maintenance problem becomes serious. Also, in order that these instruments be capable of supplying reliable information, they must be calibrated periodically under laboratory conditions. It is in the solution of this problem that the Experiment Station hopes to assist the Civil Defense effort.

IV. PROGRAM FOR THE NEXT QUARTER

It is anticipated that work will continue on all of the items discussed above with the exception that an increasing emphasis will be placed on the experimental work. It is hoped that during this next quarter it will be possible to definitely establish a laboratory so that the amount of experimental work can be increased.

Respectfully submitted.

John H. Tolan
Research Physicist

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QUARTERLY REPORT NO. 2

PROJECT NO. 198

INDUSTRIAL AND OTHER APPLICATIONS OF RADIOISOTOPES

JANUARY 1, 1952, TO MARCH 31, 1952

I. INTRODUCTION

During the winter quarter the principal effort has shifted slightly from the preliminary survey of the various phases of the program, described in Quarterly Report No. 1, to the development of specific applications. It is expected that this shift in emphasis will continue until practically all of the accumulated effort of the project personnel will be devoted to the development of specific applications of radioisotopes. Not to be excluded, however, are those attendant problems of instrumentation, personnel protection, and radioactive waste disposal.

II. CURRENT STATUS OF PROJECT PROBLEMS

A. Literature Search

Quarterly Report No. 1 described a literature search that had been undertaken as one of the primary objectives of Project 198. It is now possible to plot the ultimate path of this study, state its immediate

usefulness to the project and indicate its potential value to the Experiment Station as a whole.

1. A brief descriptive outline of the overall objectives of the literature study will serve to indicate its scope and purpose. The primary objectives and borderline interests contained within the confines of "Industrial and Other Applications of Radioisotopes" embrace nearly 20% of the entire A.E.C. unclassified research effort. For example, a brief perusal of one annual index of Nuclear Science Abstracts will indicate literally hundreds of research papers on just one subject of interest to the project. The problem of how to classify and make use of this material is not one having a simple solution. The classification of this material will be accomplished systematically in three steps as follows:

a. The collection of abstract numbers pertaining to fields of interest as taken from the annual index of Nuclear Science Abstracts.

b. A cross-indexed card file containing abstract number, title, author, report number, date, and mode of publication. This will be supplemented by a file of Nuclear Science Abstracts themselves, which may be referred to for additional information.

c. The accumulation of the most significant papers on a specific topic collected for convenience for use at the Experiment Station. This will supplement the complete file of such papers which will be in the Tech library.

2. Occasionally the procedure outlined above will be violated, when the need warrants such a violation, but without detracting from the overall plan. For instance, such a need now exists for the accumulation of information on the applications of radioisotopes to industry and medicine. This information will be reviewed and consolidated into a comprehensive report on the subject for publication on or about July 1, 1952.

3. It is conceivable that the program described above may form the nucleus for a technical report library encompassing all the major fields of interest of the Experiment Station. While this possibility is necessarily remote, its very suggestion demands that care be taken in this initial effort. In any case we cannot discount the need for such a report library, and we should plan for its existence even though the probability of this existence is low.

B. Cobalt Needles

The project for the preparation of interstitial and intracavitary cobalt 60 needles which was mentioned in Quarterly Report No. 1 has not yet started. The interim period was required by Emory University, as the contracting agency, to complete a statement of their exact requirements. As of the close of the period covered by this report, the statement of requirements was nearing completion and it was expected to be delivered in the near future. It appears that work on this problem will commence during the Quarter ending June 30, 1952.

C. Nuclear Measurements Equipment

The purchase of equipment for a nuclear measurements laboratory is proceeding at a rapid rate. This was the result of having a sum of $4000 made available in addition to the original project appropriations. The equipment which will be ultimately purchased with these funds will form the basis for a complete laboratory having facilities for scintillation, Geiger-Mueller and proportional counting of a wide variety of sample sizes and shapes and covering the gamut of radiations of nuclear origin.

Preliminary plans are underway to attempt to mesh our equipment purchases with those made by the School of Physics so that a maximum of flexibility will be achieved. It would be desirable also to attempt a cooperative operation of this laboratory for the mutual benefit of the Experiment Station and the School of Physics.

D. State Civil Defense Agency Projects

In the development of a mutual assistance program with the State Civil Defense Agency, the following items can be reported:

1. The Civil Defense Agency is intensely interested in having the Experiment Station take off their hands the problem of maintenance, repair, and calibration of their survey instruments. The initial arrangements have been made with the Civil Defense authorities concerned, and the actual program should begin during the next Quarter.

2. Another proposal under consideration is the establishment at the Experiment Station of a pilot laboratory to measure the alpha particle contamination of air borne dusts following an atomic explosion. It is expected that most of the equipment and all of the personal services required of this program will be financed by the Civil Defense Agency.

3. For the calibration work mentioned above, a special device is required. This is an instrument which will permit accurately timed

exposures by a radiation source of known intensity. Such an instrument is of particular importance in the calibration of film badges to be used for personnel monitoring work. The basic design and cost estimates for this unit have been submitted to the State Civil Defense Agency. If approved, this instrument will be constructed by and located at the Experiment Station as a part of the maintenance and repair laboratory.

E. Civil Defense Training

In cooperation with the Atlanta Metropolitan Civil Defense Agency, the personnel of the Physics Division and in particular the personnel of Project 198 are developing an instructor's course for the training of Radiological Monitors. The time devoted to this course by the personnel concerned will be in addition to their regular working time, and hence represents something outside of regular project work; but at the same time represents a part of the whole effort in support of the Civil Defense Program.

F. Therapy Unit

The development of a therapy unit using cobalt 60 or cesium 137 as a source of high intensity gamma radiation for use at the Steiner Cancer Clinic, Grady Memorial Hospital, is held in abeyance for the time being. The possible construction of such a unit hinges almost entirely on the future availability of cobalt 60 or cesium 137 of sufficiently high specific activity to concentrate a source of 1000

or more curies* into a volume of useable dimensions. The prospects for having a suitable source within a year are remote. What is often overlooked, however, is that this situation will continue unless an order is definitely placed so that a position in the long queue is assured.

G. Radiographic Source

The project has ordered a cobalt 60 radiographic source together with a shielded container and remote handling device. This source will be used to supplement the existing X-ray equipment now available for industrial radiography. It is anticipated that this source will be useful also for various experimental procedures requiring a source of small physical dimensions emitting gamma radiations of high energy.

III. FUTURE PLANS

The most urgent need of this project is the same as that of other projects at the Experiment Station, that is provision for adequate space. It seems appropriate here to outline the space requirements of this project in the order of time that it must be made available.

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*The curie is now defined as that quantity of a radioisotope necessary to provide 3.7×10^{10} disintegrating atoms per second. Since the gamma ray spectrum produced by disintegration is different for each radioisotope, the curie cannot be used as a unit of radiation intensity unless the particular spectrum of the radioisotope is stated. Unfortunately this unit has widespread use without any mention made of conditions which validate its use. Another unit called the Roentgen per hour at one meter (rhm) - which specifies exactly the information required, that is the ionization produced per hour at a point one meter from the source - is slowly replacing the curie.

A. Available During Quarter Ending June 30, 1952.

1. The maintenance and repair laboratory to be established for the State Civil Defense Agency will require a working area for one man with space available for the storage of instruments to be repaired and for the operation of appropriate test equipment.

2. The loading of cobalt needles for Emory University will require a relatively isolated space for one man together with the equipment necessary to prepare the needles.

3. The radiographic source can be stored temporarily in the existing X-ray laboratory, but care must be taken to assure its use by authorized personnel only.

B. Available During Quarter Ending September 30, 1952

The equipment which is now on order for a nuclear measurements laboratory will be delivered during this Quarter. For the proper use of this equipment, certain criteria for the selection of space are necessary. For instance, the room should have as low a natural background radiation as possible, the room should be provided with constant temperature and humidity facilities, the power source for the room should supply a constant voltage without random surges, and it should be relatively soundproof.

C. Additional Space

It may be necessary to request additional space during these same periods if proposals under consideration materialize more rapidly than is presently anticipated.

Approved by:

J. E. Boyd
Head, Physics Division

Respectfully submitted,

John H. Tolan
Research Physicist

GEORGIA INSTITUTE OF TECHNOLOGY
ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA

November 2, 1955

Memorandum

To: Members of State Advisory Committee on Radiological Defense.

From: J. H. Tolan

Subject: Report on Aerial Radiological Monitoring Techniques

At the invitation of the Federal Civil Defense Administration, I participated during the week of October 16 in a demonstration of aerial radiological monitoring equipment developed by the Atomic Energy Commission. The interest on the part of the AEC in this equipment stems primarily from their need of monitoring relatively large areas of land and water during tests of weapons in the Pacific. The interest of the FCDA stems from their anticipated need for a rapid evaluation of large areas of radiological contamination on a nationwide basis.

Prior to the demonstration in Nevada, members of the staffs of the FCDA and the AEC discussed this common problem; and the AEC volunteered to provide at their own expense the personnel, equipment, and facilities required to indicate the status of their equipment. The FCDA in turn provided travel funds (but not living expenses) for the participants who represented civil defense organizations at the local, state, and federal levels. The facilities of the Nevada Test Site, Mercury, Nevada, were made available by the AEC for the project. A list of the participants is attached for reference.

The equipment demonstrated had been developed to satisfy a very special requirement of the AEC, and was not presented as necessarily satisfying CD requirements. The system as a whole was designed to cover an intensity range on the ground from background (about 10^{-5} r/hr) to an upper limit of about 10^{2} r/hr of gamma radiation. For CD applications, it is apparent that this range could be conveniently shortened to about 10^{-2} - 10^{2} r/hr.

The detector unit utilized two separate scintillation heads -- each to cover a portion of the entire range with one decade overlap. The response of the detector unit and amplifier was logarithmic, so that uniform coverage of each decade of range would be permitted. The continuous current output of the photomultiplier tubes was presented as a voltage output proportional to the logarithm of the intensity as seen by the aircraft. The sensitivity of the detector was adjusted (calibration) by an adjustment of the first photomultiplier dynode voltage and by adjusting the fixed bias on the grid of the amplifier tube.

The output voltage of the amplifier was monitored by an Esterline-Angus, 0-1 Ma, strip chart recorder. This recorded information provided backup data if the rest of the system failed. Following the amplifier a voltage was added to the signal that was proportional to the attenuation introduced by the altitude of the aircraft. This altitude compensation was automatic in operation and was mechanically driven by the indicator of a radar altimeter. The actual compensation factor was provided by a hand-wound potentiometer which produced the proper voltage ratio to correspond to the air-to-ground intensity ratio. The new signal produced was proportional to the logarithm of the intensity of radiation on the ground. This resultant signal was then telemetered by radio transmission to the control station, and a second Esterline-Angus recorder monitored the signal.

For the demonstration in Nevada, a ground based radar unit was used to track the aircraft over the area of contamination. This was necessary because the size of this contaminated area was quite small and topographic navigation would not be sufficiently reliable. In a CD application over an area of hundreds to thousands of square miles, topographic navigation would be reliable enough.

The equipment carried by the aircraft, while necessary for the application it was designed for, could be simplified for CD use. Since the range of intensities measured can be shortened, the detector unit using two scintillation heads could be simplified to a single scintillation head. The telemetering system used might be removed completely since the plot of the data

could wait until the aircraft returned, or the data might be transmitted by voice communication. The altitude compensation factor might be supplied on the ground rather than automatically adding it to the data in the aircraft. These are some of the ways in which the equipment might be simplified for CD applications. The actual degree of simplification will depend on the requirements of the CD organization and the funds available for equipment.

At the present time, the FCDA has made no commitments of funds for development of aerial radiological monitoring equipment. When and if such commitments are made, they will probably be made to satisfy the requirements of a rapid rough survey on a nationwide basis. This type of apparatus will not necessarily satisfy the needs of the State of Georgia or the City of Atlanta. However, the basic responsibility of taking the first step in this development should rest with the FCDA, then with the State of Georgia.

A statement of the opinion of the undersigned in this regard is expressed in a letter to Mr. Dean Pohlenz, a copy of which is attached for the information of the members of the Advisory Committee.

Respectfully submitted,

John H. Tolan

U. S. ATOMIC ENERGY COMMISSION
NEVADA TEST SITE

AERIAL RADIOLOGICAL MONITORING EXERCISE
OCTOBER 17-21, 1955

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GEORGIA INSTITUTE OF TECHNOLOGY
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ATLANTA, GEORGIA

COPY

October 27, 1955

Mr. Dean Pohlenz
Deputy Assistant Administrator
Planning Staff
FCDA National Office
Battle Creek, Michigan

Dear Mr. Pohlenz:

Please accept my appreciation for the opportunity to participate in the aerial radiological monitoring exercise held at the Nevada Test Site during the week of October 16, 1955. The exercise clearly demonstrated the feasibility of the aerial monitoring technique and emphasized the need for development of equipment for Civil Defense applications. This development must of necessity come from the national level of the Civil Defense organization, and I sincerely hope that the Planning Staff of the Federal Civil Defense Administration will incorporate this development in their budget and in their future requests for appropriations.

The State of Georgia should consider this technique in their planning on radiological monitoring, and the Advisory Committee on Radiological Defense will be informed of the present status of equipment so that they will be prepared to properly advise the State of Georgia. However, this committee in the several years of its existence has yet to be asked for advice on radiological problems. That there remains a small quantity of public spirit on the part of this committee is truly amazing.

The City of Atlanta will follow the development of aerial radiological monitoring techniques with a great deal of interest, but will be looking for guidance from the state and federal level.

Sincerely yours,

/s/ John H. Tolan

John H. Tolan
Research Physicist

JHT/vr

cc: Mr. Elliott Jackson
Gen. George J. Hearn
Mr. Thomas H. Goodman
Mr. R. H. Goeke
Mr. R. L. Corsbie